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The Soviet Cement Industry: A Case Study in Slowing Growth

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A Research Paper

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The Soviet Cement Industry: A Case Study in Slowing Growth [redacted]

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A Research Paper

This paper was prepared by [redacted] Office of Soviet Analysis. Comments and queries are welcome and may be directed to the Chief, Soviet Economy Division, SOVA, [redacted]

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The Soviet Cement Industry: A Case Study in Slowing Growth 25X1

Summary

Information available as of March 1984 was used in this report.

The USSR's emergence as the world's largest cement producer reflects the industry's importance to the economy, particularly to investment and defense programs. Cement is used whenever feasible in construction to conserve metals, which are scarcer and more expensive. Moreover, a short building season encourages factory prefabrication of components, for which cement is ideal. 25X1

Nonetheless, despite its importance to construction and the economy as a whole, the cement industry—like most Soviet industries—experienced slower growth during the 1976-83 period than in the entire postwar period; in three of the years, output decreased. In our judgment, output in 1983 was up 3.2 percent, but this did little more than offset the 1982 decline. The transportation sector performed better in 1983 and probably contributed to the industry's improved performance. 25X1

During this period, production was responding, in part, to a slowdown in growth of overall demand as annual increases in new construction slowed sharply. Moreover, changes in the composition of demand in favor of difficult-to-produce, high-grade cements—particularly for the military, nuclear power, and oil and gas drilling sectors—probably strained the capacity of the industry to sustain growth. 25X1

Most of the slowdown in growth, however, resulted from mounting difficulties with raw materials and energy. As in other branches of industry, Soviet investment policy has favored construction of finished production capacity to the relative neglect of developing the requisite raw materials. Therefore, mineral raw materials are in short supply and of poor quality. Industrial byproducts might have substituted for quarry materials, but production in the industries creating these byproducts—notably metallurgy, electric power, and coal—fell short of targets in recent years. Moreover, sporadic fuel shortages have been a problem for the energy-intensive cement industry. Although many plants now rely on gas, occasional interruptions in deliveries of fuel and electric power have caused shutdowns and reduced gains in energy efficiency. 25X1

In addition to difficulties in obtaining raw materials and energy, the cement industry has had to contend with an aging and unbalanced stock of machinery and equipment:
- A large share of the industry's capital stock was built during post–World War II reconstruction and is reaching the end of its productive life.

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- Much of the new investment in the industry has been used to build bigger kilns, while relatively little has been spent on other aspects of development. Large kilns, which illustrate the Soviet proclivity toward bigness, have proved to be a technological nightmare.
- Shortages of refractory materials and their low quality have increased equipment shutdowns, which, in turn, increase wear and tear. 25X1

The cement industry, like the rest of the economy, also has been affected by labor shortages, especially a scarcity of skilled workers. While there is great potential for saving labor by automating more production processes and materials-handling tasks, the necessary investment has not been made. 25X1

A certain incompatibility of basic objectives has also contributed to the problems of the industry. Soviet planners have pursued four major goals in recent years: greater and more diversified output, better quality, energy conservation, and savings in investment costs. Progress in fulfilling one goal often has been accompanied by frustration in meeting others. Coping with these trade-offs has shaped decisions and plans for the industry. For example, substantial energy could be saved if the industry converted to the more efficient dry-process plants; however, reaching this goal could take decades and would require very heavy new investments at a time of unusually tight resource allocations. 25X1

In addition, technological progress in the industry has been hindered by a lack of integrated research, because of the organizational split between research institutes specializing in cement, the key raw material for concrete, and those specializing in concrete, the end product. Even more obstructive has been the gap between basic research and commercial application of research findings. 25X1

Under the 1981-85 Plan:
- Energy savings are to be obtained by increasing reliance on lower quality portland slag cement, promoting conversion to more energy-efficient production techniques (for example, the dry process), and developing new types of cement.
- Limited investment funds are to be spent to modernize plant and equipment and to build new, technologically advanced facilities.
- Labor productivity is to be raised by mechanizing repair, transport loading and unloading, and materials-handling work. More funds are to be spent to provide amenities for workers to induce them to remain on the job. 25X1

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Completing these tasks over a five-year period would require very large investments, but Soviet planners have allocated only 1 billion rubles of investment, only 11 percent above the previous five-year plan and roughly 0.1 percent of national investment. Sharing such limited funds among many projects is likely to reduce the effectiveness of the investments.

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Foreign trade is not a likely alternative for the balance of the decade to circumvent or solve the industry's problems. Importing raw materials or cement would prove costly and would strain the already taut transportation system. Moreover, East European countries, the logical suppliers, probably cannot, in this decade, expand production beyond their own domestic needs.

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Without foreign trade as an alternative, the intractable domestic problems of the cement industry—particularly shortages of raw materials and energy, an inefficient capital stock, and skilled labor shortages—mean that cement production probably will not return to earlier growth trends, and output may decrease in some years. These trends will constrain the nation's ability to accelerate growth in new construction in the 1980s.

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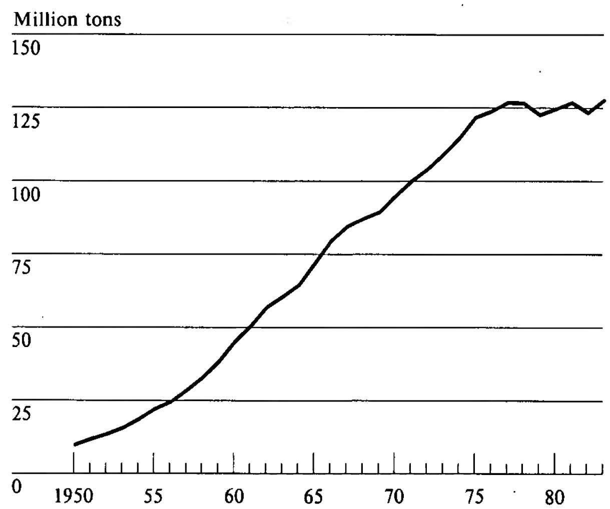
Figure 1
USSR: Cement Production, 1950-83



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The Soviet Cement Industry: A Case Study in Slowing Growth

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Introduction

The Soviet Union has become the world's largest cement producer by rapidly expanding output from the early post–World War II years to the mid-1970s (see figure 1 and table 1). As the cement industry developed, however, the high annual growth rates of the early years—often over 10 percent a year—could not be sustained. Beginning with the 1976-80 Plan period, the rate of growth declined sharply, with the average annual rate during 1976-82 falling to 0.2 percent per year. Output declined around 3 percent in both 1979 and 1982.[1] Output in 1983 was up 3.2 percent, but this did little more than offset the previous year's decline. Moreover, reinforcing this near stagnation in growth in gross tonnage since the mid-1970s has been a failure to improve quality and assortment of output.

In the early 1950s, tonnage increased somewhat faster than value, implying a slight deterioration in the average quality of cement produced (see table 2). From 1955 until 1975, the growth in value exceeded the growth in tonnage by more than a half percentage point a year, and from 1961 to 1965 by more than 2 percentage points. During 1976-82, however, the increase in average quality almost halted.

What has caused the abrupt deterioration in performance since the mid-1970s? How are Soviet planners coping? What are the prospects of restoring the industry's growth to the rates of the early 1970s? This paper first gives a brief background and places the cement industry within the context of the Soviet economy. Then, the factors holding back the industry's progress are categorized: those determined by changes in demand and those oriented to supply considerations. Finally, it discusses Soviet plans to deal with the industry's problems and the likelihood of success. The use of foreign trade in adjusting to supply constraints is given special consideration.

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Table 1
USSR: Production, Foreign Trade, and Apparent Consumption of Cement

Thousand metric tons

	Cement Production	Exports	Imports	Net Exports	Apparent Consumption
1970	95,248	3,200	481	2,719	92,529
1971	100,331	3,400	371	3,029	97,302
1972	104,299	2,100	460	1,640	102,659
1973	109,521	3,300	544	2,756	106,765
1974	115,145	3,600	489	3,111	112,034
1975	122,057	3,322	811	2,511	119,546
1976	124,246	2,882	552	2,330	121,916
1977	127,056	3,438	636	2,802	124,254
1978	126,956	3,548	592	2,956	124,000
1979	123,019	3,084	345	2,739	120,280
1980	125,049	3,245	523	2,722	122,327
1981	127,169	2,735	200	2,535	124,634
1982	123,681	2,221	254	1,967	121,714
1983	128,000	NA	NA	NA	NA

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Background

Cement is very important to the Soviet economy. First, the Soviet construction industry depends on cement more than is the case in other developed countries because cost and technical considerations limit the use of steel and nonferrous metals in construction.

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[1] Output can be measured as either tonnage, or, to capture a change in composition, value in rubles. Because the average quality of cement has gradually improved, an index of value of output would rise more rapidly than an index of physical volume. To produce high-grade (higher cost) cement requires a more than 1-for-1 decrease in production of lesser grades if everything else remains constant. Thus, the value of output could increase while tonnage drops. Unless otherwise noted, output indicators (growth rates) in this paper are expressed in physical terms.

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Table 2 *Percent*
USSR: Average Annual Growth of Cement Production and Value

	Tons	Value
1951-55	17.1	16.9
1956-60	15.1	15.8
1961-65	9.7	11.8
1966-70	5.6	6.1
1971-75	5.1	5.6
1976-82	0.2	0.2

Second, Soviet emphasis on precast concrete means that a large share of the cement is used for products such as bathroom modules, walls, and even railroad ties. In 1980 more than 40 percent of all cement manufactured in the USSR was used in precast concrete products; in the United States, only 13 percent. Despite the numerous problems in scheduling the manufacture and delivery of concrete components, the factory assembly of these components avoids some of the limits imposed by a relatively short construction season in the USSR. On-site use of concrete in the frigid weather prevailing for half of the year in much of the USSR rapidly raises costs and creates technical difficulties. Special temperature-control measures are used during the hardening process, and extra labor and materials are needed to prevent the concrete from sinking into the frozen ground as heat is emitted during the hardening process.

The cement industry has had four major goals during the last few years: to increase and diversify output, to improve quality, to conserve energy, and to minimize investment requirements. These targets are largely contradictory. Coping with their trade-offs has affected technological decisions and plans for the industry. For example, the technology employed in cement production is a major determinant of the industry's performance relative to these goals. Particularly important is the choice of which basic process to use: the wet or the dry process (see box, page 4). Wet-process plants are not as demanding of quality raw materials, but they use at least one-third more energy per unit of output than an equivalent dry-process plant. Although the dry-process plant uses less energy, it requires initial higher investment expenditures. The high energy costs of the 1970s encouraged conversion of much of the world's cement production to the dry process. While the Soviet Union also has moved in that direction, it has done so much too slowly, according to some Soviet experts, and lags behind most Western countries (see figure 2 and table 3). 25X1

Changing Demand

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Our analysis suggests that slower growth in overall demand was not central to the deceleration in cement production, but it did have an impact. In particular, increasing demand for difficult-to-produce specialty cements probably did contribute to slowing growth. Further, while requirements for a higher average quality of cement were not met fully, attempts to meet them probably lowered production growth. Although the industry has for a long time been handicapped by having to produce a wide variety of cement types and strengths, we judge that an increase in the number of different cements produced probably explains only a small part of the difficulties in the cement industry since 1975.[2] 25X1

Overall Demand

A part of the slowdown in the growth of cement production during the 1976-80 Plan period was expected. Cement output was to grow by only 3.4 percent per year during the 1976-80 Plan, a rate slower than the 5.6 percent growth planned and 5.1 percent achieved for the 1971-75 period. This reduction in planned growth resulted from slowing capital investment to less than 3 percent a year—only one-half of the rate planned for the early 1970s. However, the Soviets failed to meet even these reduced targets in every year since 1976. This contrasts with the previous plan where the annual target was reached every year. In fact, performance from 1976 to 1980 was so far below plan that the 1985 target is less

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[2] For a discussion of basic types of cement, see box, page 7. 25X1

Figure 2
Shares of Total Cement Production by Process, 1970 and 1980

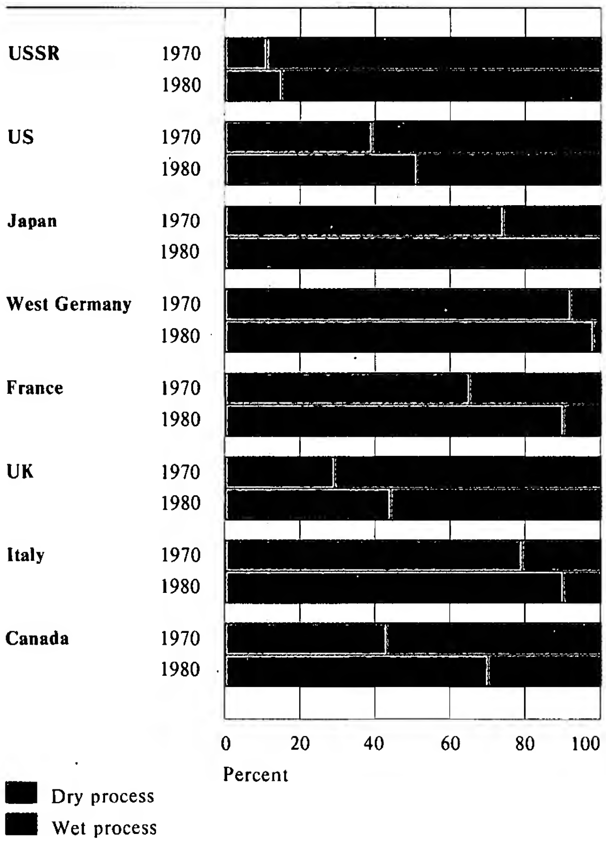

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Table 3
USSR: Share of Cement Production by Dry-Process plants

Year	Percent
1960	11.2
1965	11.6
1970	11.3
1972	10.8
1973	10.7
1975	12.1
1977	13.0
1978	13.2
1980	
Plan	18.0
Actual	14.6
1981	
Plan	15.0
Actual	15.0
1985 plan	16.9-18.0
1990 plan	21.0-22.0

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than the original 1980 target—which itself was underfulfilled by 20 million tons.

Demand for Wider Assortment

The problems of the cement industry result partly from the large assortment of products included within three basic types of cement (see box, page 7 and table 4). The use of a variety of types and strengths has both advantages and disadvantages. The Soviets can economize by using low-quality cement for those applications where strength is not a consideration and can customize cement to its application. The proliferation of cement types and strengths, however, increases the need for cement storage facilities, slows the packing and transportation process, and requires more adjustments and interruptions to a smooth rhythm of production. Moreover, even if a smooth production flow is maintained, storage or transport bottlenecks often have forced using a high-quality product where low quality would be suitable or the mixing of various grades of cement, thereby raising average cost per unit of construction and causing bottlenecks at other construction sites where higher quality cement usage was targeted. On balance, under Soviet conditions, where price and profit incentives are absent, the practical disadvantages of a large assortment probably outweigh the presumed benefits. 25X1 25X1 25X1

The demand for specialty cement appears to have increased during the 1970s. In particular, requirements of the military as well as the electric power, oil, and gas industries have raised demand for cements that are more difficult to produce. These special requirements have contributed to holding back the

The Wet and Dry Processes for Making Cement

Cement is produced by combining limestone, clay, gypsum, and other additives in defined proportions. Production can be divided into five stages: extracting the raw materials, preparing the raw material mixture, firing the mixture, grinding the material into the final product, and storing, packing, and distribution. Figure 3 shows the wet-process production. [redacted]

The raw materials are mined in two basic ways. Soft inputs, such as chalk and clay, are extracted by using a high-pressure stream of water. Harder substances, such as limestone, are mined in quarries by first stripping the overburden from the materials, loosening the rocks with explosives, and then loading the fragments into a dumptruck or railcar. [redacted]

At the second stage, the technique varies with the process. [redacted] *The geologic properties of the available quarry materials in turn help determine which process is selected. Materials with natural moisture, heterogeneous chemical properties, or that mix easily in water are most appropriate for the wet process. The dry process is most suited to materials possessing low natural moisture, homogeneous chemical composition, and low alkali content. Geologic criteria alone would indicate that most of the cement industry should be wet process, as indeed it is.* [redacted]

The raw material mixture stage in a wet-process plant combines the quarry materials in a slurry consisting of about 40-percent water. After the slurry is ground and crushed in mills, it is pumped into cylindrical basins for stirring, adjusting of chemical proportions, and storing. In contrast, dry-process plants dry the quarry materials before grinding and mixing to create a mixture that is warmed in preheaters before entering the kiln. [redacted] 25X1

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The firing phase for each process begins with the entry of the raw materials into a cylindrical rotary kiln. Some of these extremely large Soviet kilns are nearly two football fields long. Because the rotary kiln is the largest and most expensive piece of equipment, it is generally the key element in any cement plant and the source of many problems. The kilns are inclined at a slight angle and rotate slowly so that the centrifugal and gravitational action forces the raw materials to pass through the kiln where they are burned at temperatures over 1,400 degrees C. The small pellets that exit from the kiln—called clinker—then pass through coolers. [redacted] 25X1 25X1 25X1

Next the clinker is mixed and ground with gypsum in varying proportions to achieve the desired cement properties. Other ingredients—including blast furnace slag, fly ash, and other substances—may be added to give the cement special properties. After final grinding, the cement is stored in silos for a few days for further cooling before being packed in bags or shipped in bulk to the destination. [redacted] 25X1 25X1 25X1

growth in cement output by consuming a disproportionate share of the resources available to the industry. Because the growth of military construction has exceeded the growth of cement production since the slowdown began in the cement industry, direct defense requirements probably have imposed an ever-increasing burden.[3] Military construction peaked in 1970, declined until 1975, and resumed an upward trend during the 1976-80 Plan period (see figure 5). Military-related construction in 1980 was 16 percent above the 1975 level. The military is a major consumer of the high-strength cements for missile silos, silo cores, airfields, and many other projects. High-strength cements require special handling and storage, which the Soviets are often unable to provide; the resulting high losses from spoilage cause the demand for these cements to have a disproportionately higher

[3] Military construction entails facilities directly supporting weapon systems and personnel (silos, airfields, and barracks) and those that increase combat readiness and endurance (personnel support structures, maintenance buildings, and vehicle, POL, and ammunition storage facilities). This measure excludes construction of factories that produce military hardware [redacted]

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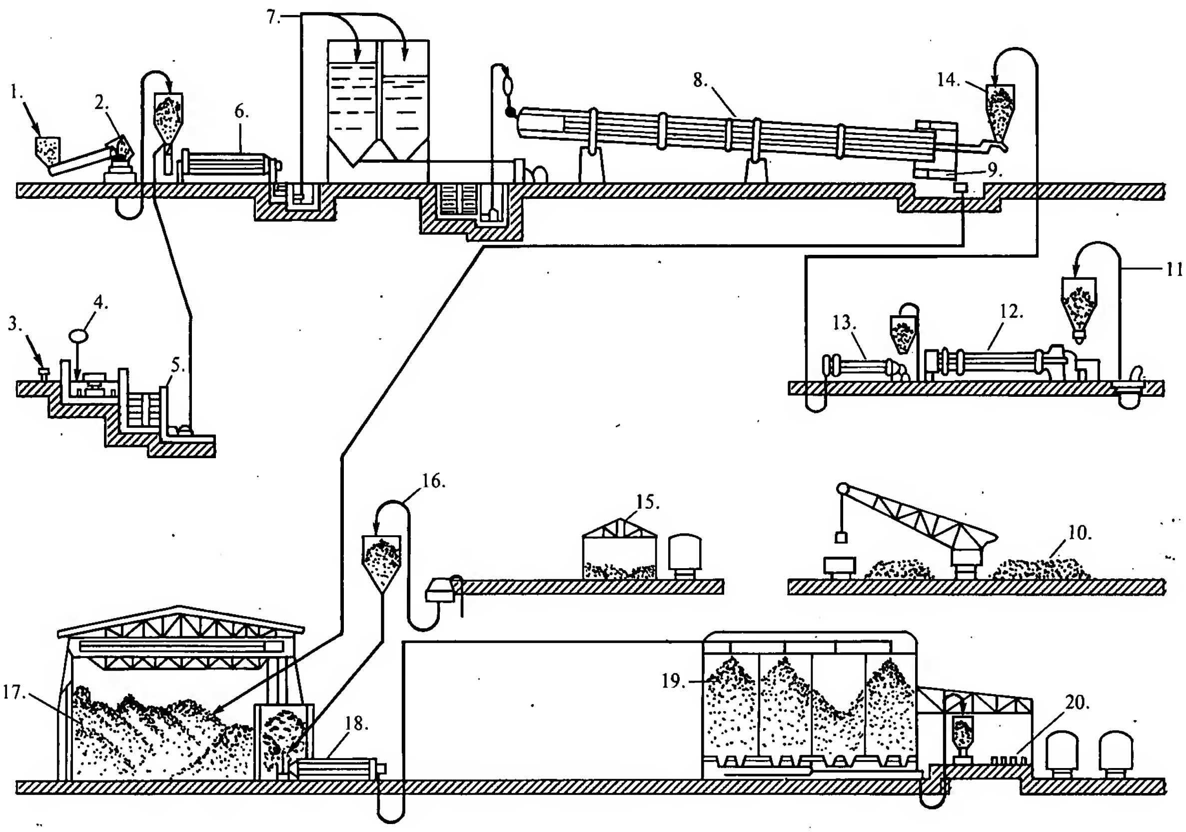
Figure 3
Production of Portland Cement by the Wet Process



1. Limestone from the quarry.
2. Crushing for limestone.
3. Clay from the quarry.
4. Water.
5. Basin for mixing the clay.
6. Raw material mill.
7. Slurry basin.
8. Rotary kiln.
9. Cooler.
10. Coal warehouse.
11. Elevator for feeding coal from the crusher to a bunker.
12. Drying cylinder for coal.
13. Coal mill.
14. Pump for feeding coal dust.
15. Gypsum storage.
16. Elevator for feeding gypsum from the crusher to a bunker.
17. Clinker storage.
18. Ball mill.
19. Cement silos.
20. Packaging.

Source: V. N. Kropotov, A. G. Zaytsev, B. I. Skavronskiy, *Stroitel'niye Materiali*, (Visshaya Shkola; Moscow, 1973), p. 135.

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claim on total cement resources (see box, page 8). In addition, the higher clinker content and finer grinding require substantially increased energy use. To satisfy these demands from the military, cement producers in some cases have had to reduce their overall output.

Demand for Higher Quality

Since the early days of postwar reconstruction, Soviet planners have struggled to improve the quality of cement. However, progress has been too slow to account for the slowdown in the growth of production tonnage, as a comparison of the rates of growth of cement production measured in tons and in value (with individual grades of cement valued in constant prices) shows (see table 2).

Additional improvements in strength have become progressively difficult. To replace 1 million tons of Mark 300 cement by an equal amount of Mark 400 requires an extra 140,000 to 160,000 tons of clinker, 30,000 to 35,000 tons of fuel, and 5 million rubles of investment. Shifting production to even higher strengths causes disproportionate increases in costs. Offsetting these costs is the fact that increased strength lessens the amount of cement that is needed. In many types of construction, increasing strength by one mark permits a 15-percent reduction of cement.

Like the military, the nuclear power industry requires high-quality cement, which it uses for containment buildings and other heavy-duty structures at nuclear plants. Such construction requires special polymer cements to reduce the possibilities of cracks and leaks, especially where temperatures are extremely cold or fluctuate widely. Construction of nuclear plants accelerated after 1975; investment in nuclear power plants

Basic Types of Cement

Three basic types of cement are relevant to the analysis in this report: portland, portland slag, and portland pozzolan. Portland cement, the most common cement produced in the USSR, has grown in importance as the Soviets have tried to improve product quality. (In the United States, portland cement accounts for more than 90 percent of output.) To stretch supplies, the Soviets produce ordinary portland cement in two forms: unadulterated and adulterated using about 15 percent of other materials, including natural minerals and artificial substances such as blast furnace slag, alumina waste products, or fly ash.

Although it is cheaper to produce than ordinary portland cement, slag cement has diminished in importance during the last two decades because of its relatively low strength in the face of rising requirements for higher quality cements. It is even less suitable in the USSR than in the industrial West because it does not stand up well under cold temperatures.

Portland pozzolan cement mixes clinker with various minerals and burnt clay or fly ash. Generally considered inferior, it is even more costly than slag cement. Its use is confined to some special construction, such as underwater and underground, where the concrete is exposed to considerable moisture.

A key measure of cement quality is its compressive strength after 28 days. In the Soviet Union, the cement is tested and then given a "mark"—its strength measured in kilograms of pressure per square centimeter. A higher mark indicates higher strength. Strength can be increased in three ways: higher clinker content, finer grinding, or the injection of special additives.

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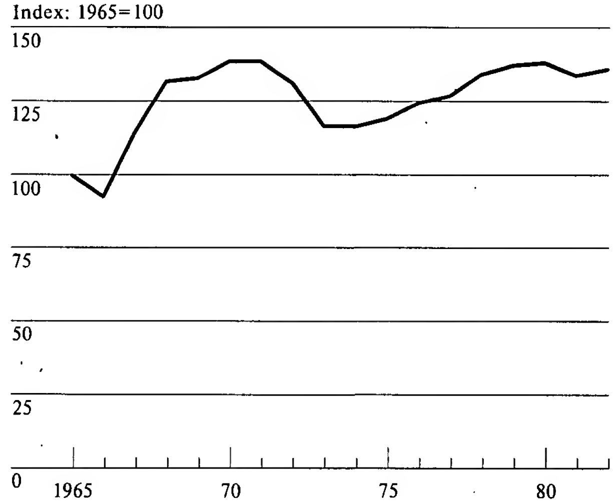
during 1976-80 was about 2.5 times the level of the first half of the decade.

Meanwhile, the rising volume of oil prospecting and drilling from 1975 to 1980 increased requirements for a special oil well cement. Its production grew 5 percent a year during this period, although periodic

Figure 5
USSR: Growth in Military Construction Expenditures, 1965-82[a]



[a] Based on estimates in 1970 rubles.

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shortages have hampered oil and gas exploration. Oil well cement sets slowly so that it can be pumped down into the wells, harden rapidly, and withstand high pressures. Growth in production of oil well cement, because of its special requirements, may also have inhibited the overall growth of production in the 1976-80 period. 25X1

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The steady growth in demand for high-quality cement from the military construction, nuclear, and oil and gas sectors implies a decrease in the quality of cement for residual users, since the average annual rates of growth in tons and value were the same during 1976-82 (0.2 percent, table 2). 25X1

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Supply Considerations

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Although the changing nature of demand for cement played a role in the deteriorating production figures, we judge the main problems are on the supply side. In particular, constraints on raw materials, energy, capital, and labor played varying roles in the production slowdown. 25X1

Waste Not . . . Want Not

Not only is the Soviet Union the world's largest producer of cement, it probably is also the largest waster of cement. According to a 1982 article in Stroitel'naya gazeta, *about one-eighth of all cement produced is lost, spoiled, or stolen before it can be used. One Soviet expert has equated these losses to the annual output of five to eight large cement plants, or the amount of cement used to produce 1.3 million dwelling units. Of course, stolen cement (for example, that used in the construction of private homes) is not "wasted." However, from the viewpoint of the state planner, it results in bottlenecks and disruptions in planned uses.*

Because there has been a longstanding shortage of appropriate conveyances for transporting cement, the transportation sector is the chief culprit in this tale of waste. Cement usually has been transported in open vehicles, primarily trucks and hopper cars, that do not provide appropriate protection against the elements. In a recent year, more than 80 percent of cement was transported by rail, and three-fourths of that was carried in open rolling stock. As a result, large quantities of cement either blow away or leak from their conveyances or are exposed to rain and snow, which reduce quality. Occasionally, jackhammers have been necessary to empty trucks of hardened cement. The notorious delays and wasteful crosshauling in the transportation system compound these problems. (Crosshauling occurs when a product is shipped to a location while an equivalent product is shipped the opposite direction.) Because of their greater perishability, higher grade cements are even more vulnerable to transportation problems, and the ensuing spoilage is even more significant. The large amount of wastage suggests that cement consumption could increase considerably without an expansion in output if the transportation problems could be corrected. However, no significant changes seem likely.

Shortages of Raw Materials

We judge that dwindling supplies and deteriorating quality of raw materials—including quarry minerals, industrial byproducts, and special additives—have been the principal cause of the slowdown in the cement industry. Because cement technology presents few opportunities for reducing raw material use per unit of output, production cannot increase without nearly proportional increases in raw material supplies. Complaints concerning the absence or poor quality of raw materials have been frequent in the industry journals. According to one Soviet study, raw material shortages accounted for nearly one-tenth of the drop in output in 1979. Another one-third of the decline in production resulted from difficulties in processing the raw materials, which in turn reflected use of low-quality minerals as increasingly marginal sources were exploited (see box, page 9). 25X1

25X1 The Soviets, as they have with other extractive industries, are paying for planning errors in neglecting to develop raw material deposits. The use of quarry materials has outstripped the discovery of new deposits and created bottlenecks. In 1981, for example, gypsum shortages impeded production at several plants. 25X1

Quarries are becoming depleted. Increasing average plant size has accelerated the depletion of quarry reserves. Most of the expansion in capacity has been obtained by expanding plants rather than by building new plants close to new supplies. This tactic means that in a specific location a limited amount of minerals is now thinly spread among more kilns. The Soviets, believing that large cement plants are more efficient than small ones, prefer plants in the range of 2-3 million tons a year, or more than four times the size of the average plant in the United States. But only about one-half of the current quarries can support plants of this size.[4] 25X1

The minerals needed for cement are not uncommon, but the deposits are seldom concentrated in amounts adequate for commercial exploitation. The only way to increase reserves at existing plantsites to acceptable

[4] To compensate for inadequate mineral reserves nearby, cement plants could obtain minerals from other sources. If distant quarries were used, transport costs would rise, further burdening an overextended rail network. These minerals, moreover, have low value relative to other freight, and the low priority accorded them would cause many delays in deliveries. 25X1 25X1

Why 1979 Was a Bad Year for the Soviet Cement Industry

In 1979 the value of cement production, for the first time since 1950, fell below the level of the previous year (down 3.1 percent). Official Soviet statistics indicate that average strength of the cement also declined, although by a lesser amount. This unprecedented decline received considerable attention in the pages of Tsement, *the industry journal. One author assessed the relative importance of problems in various parts of the work flow:*

	Percent
Extracting and preparing raw materials	34
Burning the clinker	15
Grinding the cement	15
Measuring the components	12
Working the equipment	10
Lacking raw materials and other cement components	9
Transporting the products	5
Total	**100**

The percentage distribution represents the number of times each stage of production figured in production failures, but it does not necessarily correspond to the relative importance of each factor in the national slowdown in cement production. Although the author was referring to problem areas for 1979, this list provides a menu of the endemic problems facing the industry.

levels is to increase the depth of excavation, but doing so doubles or triples costs per ton. In addition, the requirements that dry-process plants place on the composition of the raw material base—low-moisture content and homogeneous composition—are so stringent that they are found at less than 10 percent of operational deposits in the USSR and at only 4 percent of explored deposits, according to analysis in a 1976 article in *Tsement.*

Industrial byproducts—such as slag from the ferrous metals industry, some waste products from the nonferrous metals industry, and fly ash from electric power plants—could help compensate for inadequate supplies of minerals, but they are in short supply because of shortfalls in metals production and the decline in the use of coal to generate electricity. Seventeen cement plants (about 15 percent of the total) are near iron and steel facilities, and most new cement plants are required to find similar locations. The ministries producing these byproducts, however, have been criticized for not cooperating with the cement industry; such cooperation diverts resources from contributing to the most important element of their own plan and increases competition for the limited quantities of railroad rolling stock.

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Even if these byproducts were freely available, the cement industry would need to make other adjustments. The byproducts are harder to heat than quarry minerals because of their lower plasticity and cohesion, and more modifications must be made during production to deal with nonuniform composition. Sintering or agglomeration might be employed to preprocess these byproducts, as the ferrous metals industry beneficiates iron ore, but the question would arise as to which ministry would pay for such processing at a time when investment funds are unusually tight.

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Special additives also have become scarce. In 1981, for example, an extreme shortage of SNV, an essential resinous additive for cement exposed to extreme cold, restrained production. The Tikhvinskiy Wood Chemical Plant, the only SNV production facility, met only 60 percent of its 1981 plan goal. Moreover, the plant indicated to central authorities that it will eventually halt SNV production entirely, probably because of the small contribution it makes toward meeting the plant's ruble output goal. Perhaps as an indication of disarray in the planning process, the Ministry of Pulp and Paper refuses to make the only alternative substitute.

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In many cases the Soviets have not provided adequately for long-term availability of mineral supplies at specific locations. In selecting a site for a plant, Soviet cement experts are supposed to require that the plant's quarry have at least 30 years of reserves; in US

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practice, 50 years of reserves are considered necessary for a plant to be economically feasible. The Soviets have not always adhered to even the 30-year rule; at least two plants were built with only seven years of reserves.

Shortfalls in Energy Supplies

Energy is no less important than the basic raw materials in the production of cement. One of the most energy-intensive industries in the USSR, cement accounts for 1 percent of domestic fuel consumption (2.5 percent of gas consumption) and about 1 percent of electric power generation. Some four-fifths of the energy is used for burning clinker; most of the remainder is used for crushing and grinding.

Sporadic shortages of coal, gas, oil, and electric power have all been blamed by industry managers, economic officials, and the Soviet press for periodic bottlenecks and resulting slowing of industrial production growth during the last few years. As in other industries, the core of the energy problem for the cement industry is not the overall level of supply but the interruptions in delivery. For example, gas supplies to many industrial customers frequently are curtailed or even halted during winter, forcing either a production stoppage or a shift to less efficient fuels (see box).

Meanwhile, growth in fuel efficiency slowed somewhat before the slowdown in the growth of output.[5] Failure to meet planners' targets for growth in fuel efficiency has led to overuse of energy and, thus, has contributed to the imbalance between fuel supply and requirements. The fuel used per ton of clinker declined by more than 1 percent a year until 1974 (table 5). Except for the 1966-70 period, energy efficiency in cement production improved more slowly than for clinker, because the clinker content in cement was increased to improve the quality of the product. Most of the improvement in fuel productivity resulted from a dramatic shift in the structure of fuel use by the industry (table 6). During the 1960s and early 1970s, the industry decreased its reliance on coal, replacing coal with more efficient gas and oil. Oil, for example,

[5] Fuel efficiency is measured in terms of the caloric content of fuel that is consumed per ton of output, where output is measured as either clinker or cement. The rate of growth varies depending on whether cement or clinker is used as the output measure, because the clinker content of cement can be varied.

Problems Caused by Energy Interruptions

Interruptions in energy supplies to cement producers, especially during winter, create various difficulties. 25X1
For example, Soviet cement plants in winter face a trade-off similar to that of US plants, which must choose between using 15 percent more energy to keep output constant and to offset heat loss or cutting production by 10 percent to keep energy use constant. Reduced deliveries of electric power would stop grinding operations and eventually force kiln shutdowns. More than a few days of production would be lost. Stopping and refiring a kiln shortens the life of the refractory materials used in the kilns and causes 25X1
more frequent shutdowns for repair and relining. An unanticipated shutdown causes even more damage than one for which there is warning. Restarting a kiln in a wet-process plant during the winter is extremely difficult because of freezing of raw materials, the bearings in the gear mechanism, or both. 25X1

requires only 70 percent of the caloric content of coal to make cement. 25X1

The growth of energy efficiency slowed and in some cases actually stopped after 1973: 25X1

- Fuel efficiency per ton of clinker did not improve during 1974 and 1975 and managed less than one-half of its 1961-73 annual growth during 1976-80.
- Fuel efficiency per ton of cement decreased from 1974 to 1980.
- The efficiency of electricity use in producing cement also decreased after 1972. 25X1

Apparently the improvements in energy efficiency characteristic of the 1960s were driven by a shift in fuel mix from coal to gas and oil. Once the transition had ended, the cause of increased efficiency was removed. The rising average age of plant and equipment in the industry also has pushed up fuel requirements. During the late 1970s, moreover, the raw-materials bottlenecks, the lower quality of inputs, and the frequent shutdowns for equipment repair tended to offset slight technical improvements in energy efficiency so that the overall effect per ton of cement

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Table 4
USSR:
Cement Production by Type

Percent of total production

	1950	1960	1970	1980	1981
Portland	51.9	44.6	63.9	68.1	66.5
Portland slag	32.1	36.5	27.4	27.1	28.5 [a]
Portland pozzolan	11.5	17.1	6.8	3.6	3.6 [a]
Other	4.5	1.8	1.9	1.2	1.4 [a]

[a] Estimated.

Table 5
USSR: Energy Efficiency in the Cement Industry [a]

	Fuel Consumption	
	Per Metric Ton of Clinker Produced	Per Metric Ton of Cement Produced
1961-65	−2.3	−0.3
1966-70	−1.0	−1.4
1971-73	−1.0	−0.7
1974-75	0.0	0.8
1976-80	−0.4	0.2
1981-85 plan	−0.8	NA
1986-90 plan	−0.6	NA
	Electric Power Consumption Per Metric Ton of Cement Produced	
1966-72	−0.4	
1973-75	+0.2	
1976-80	+0.2	

[a] Average annual percentage rate of change in energy consumption per unit of output.

Note: A negative (positive) sign indicates less (more) energy is used per unit of output.

was a loss in efficiency. Soviet cement experts are trying to reverse this deterioration in the current five-year plan; fuel efficiency per ton of clinker is to grow at double the 1976-80 rate. Although plans for fuel efficiency per ton of cement have not been announced, the goal for clinker and the intention to lower the clinker content of cement suggests that the planners are hoping for major gains in fuel efficiency for cement. With the effects of fuel substitution (gas and oil for coal) already realized, new technology and the conversion of the industry to the dry process are the remaining factors that would lead to greater energy efficiency. We doubt that they will be implemented sufficiently during the next few years to do so.

Unbalanced Allocations of Fixed Capital

Although capital productivity in the cement industry declined throughout the 1970s, the rate of decline accelerated during the last half of the decade—as it did in most Soviet industries. Evidence in Soviet technical journals shows that after declining by almost 1 percent a year from 1971 to 1975, capital productivity fell by more than 4 percent a year thereafter. Soviet authors have blamed the decline in output per ruble of plant and equipment on the inadequate supplies of raw materials (especially minerals and energy as discussed earlier) and unbalanced development of the industry's capital stock.

Because of the size and high cost of rotary kilns, they have received an inordinate share of the investment while other elements have been neglected. As indicated above, inadequate investment in quarries has reduced the availability of raw material. For technical reasons, cement plants usually are designed with excess capacity in the grinding and crushing mills to assure the continuous flow of material to the kilns, and in storage facilities for intermediate materials and finished production. Soviet planners built additional kilns without a requisite expansion of capacity on either end of the production process. Thus, a plant must quickly shut down its kilns, if:

- A temporary breakdown in a mill causes slurry to back up in the production flow.
- Storage capacity is filled.
- Railroad freight cars—often in short supply—are not available.

The priority given to investment in kilns also has diverted resources away from equipment that could automate the industry and improve the quality of the product. For example, instruments for measuring chemical composition and quality control are often absent or obsolete; the industry's technical journal, *Tsement*, pointed out that lack of this equipment is responsible for 12 percent of the instances of unacceptable quality in 1979. New pumps and material-handling equipment have likewise been accorded a low priority.

The growing age of the capital stock also has hampered capital productivity. In 1976, 30 cement plants—about one-fourth of the total—were still using equipment that had been fully amortized 10 years earlier. The planned life of a rotary kiln is 25 years. By comparing the age structures for 1972 and 1980 (table 7), we can identify the structural shift during the period when cement production was faltering. Between 1972 and 1980 the average age of kilns increased by at least 20 percent or by three years. Most kilns were built during the surge in cement output during the 1950s and early 1960s and are nearing the end of their productive lives. Thus, between 1972 and 1980, the share of kilns that has exceeded or is nearing the end of its planned life doubled.

Despite the inordinate investment given to kilns in recent years, the older kilns have, for the most part, not been scrapped. Older kilns technically are less productive than newer ones. However, the problems in getting the new kilns on stream have depressed productivity. Soviet literature has reported many problems in mastering dry kilns and 170-meter and 185-meter wet kilns. Use of these types of new kilns is only about 80 percent that of kilns more than five years old, partly because they require considerably more repair, maintenance, and refractory relining than the smaller ones. Devoting a larger share of capacity to the less reliable, high-capacity kilns puts more eggs in fewer baskets

Another reason for retaining older kilns is that apparently the new, larger kilns have uneven burning zones that lower the quality of the clinker and prevent the production of better quality cement. The older kilns must be used for these products.

Table 6
USSR: Distribution of Fuel Use in the Cement Industry

Percentage of total

	Gas	Oil	Coal	Shale and Others
1960	38	8	53	1
1965	57	16	25	2
1970	61	14	23	2
1972	60	18	21	1
1980	60	[a]	40 [a]	[a]

[a] For 1980, Soviet technical literature has published only the relative importance of gas to the cement industry. The other fuels are combined in one group.

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The reason for the extensive repair requirements for the large kilns seems to be the failure to solve many technological problems before the plants came on-stream. For example, the Soviets' inability to produce the required high-grade steel means that the walls of the 185-meter kilns must be twice as thick as desirable. This inordinate weight causes the wheels and turning mechanism to require frequent repairs, leading to a rising average proportion of downtime. Also, because of the increased length of the kiln, winter winds lead to uneven kiln temperature resulting in "bowing" of the whole kiln. Redesigning the kilns to correct the problems requires development of special bearings and subassemblies to cope with the tremendous stresses these huge kilns must endure as a result of the modifications.

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The grinding mills also have become increasingly obsolete. Their planned service life is 12 years, but, by 1972, 74 percent had surpassed this span. Improvements in cement quality due to finer grinding are expensive, because the Soviets use an older grinding method requiring a large increase in electric power consumption to improve quality. Problems with grinders accounted for 15 percent of the problems experienced by the industry in a recent year.

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Table 7 *Percent of kilns*
USSR: Distribution of Rotary Kilns, by Age

Age	1972	Estimated 1980
0 to 5 years	7	5
5 to 10 years	15	9
10 to 20 years	52	34
More than 20 years	26	52

The rising share of investment given to equipment for environmental protection has further depressed capital productivity. Although cement production is a major source of air pollution, the Soviets spent little on pollution before the 1970s. During 1971-75, outlays on pollution control devices in the construction materials industry—primarily in cement production—rose to 63 million rubles. This amount increased by about 50 percent during the 1976-80 Plan period. If we again assume that most of these outlays went to the cement industry, then more than 10 percent of capital investment for new plant and equipment during the last half of the 1970s was spent on pollution control devices with no increase in output.

Shortages of high-quality refractory materials, which are used to line rotary kilns to protect them from intense heat, have caused an increase in kiln downtime. These materials must be replaced or repaired periodically, during which time the kiln is shut down. Shutdowns are particularly lengthy for the largest kilns; the losses in a recent year were equivalent to stopping three kilns for an entire year (and losing 3 million tons of output). The scarcity of supplies has forced many cement plants to stop checking the refractory bricks for quality because there are no extra bricks to replace those that might be rejected. The poor quality of the received material is blamed for one-fourth of kiln shutdowns. For at least one major cement combine, the average length of a kiln run dropped by nearly 20 percent in 1979. For many of the 185-meter kilns, the average kiln operating time has fallen to one-third of its 1974 level.

Refractory materials have been in short supply for several reasons:

- Shortages of the most heat-resistant refractories have forced reliance on less durable materials.
- The growing share of both large kilns and old kilns in the national stock places more emphasis on kilns that are heavy users of refractory materials.
- More frequent shutdowns because of fuel and raw material shortages and kiln breakdowns in recent years have reduced the working life of refractory materials.
- Growth of refractory output has been nearly flat since 1975. 25X1

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Labor Shortages

The cement industry—like most of the economy—is suffering from labor shortages, especially for skilled workers. Moreover, the industry is considerably more labor intensive than in other countries. Western plants have mechanized a large share of auxiliary work, including transport (both within and outside the plant), warehousing, materials handling, maintenance, and repair. In the USSR this work is performed manually for the most part and accounts for more than 50 percent of employment in the industry. Even where work has been automated, the unreliability of the automated equipment has discouraged management from releasing these workers for other tasks. 25X1

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Cement industry experts attribute the high labor turnover to inadequate investment in social infrastructure, such as housing, vacation resorts, and social activity buildings. The share of such investment in total investment was 22 percent in 1960 but had fallen to 15 percent by 1979. According to a Soviet industry expert, a share of at least 25 percent is needed to prevent excessive turnover. Even if the necessary funds were available and had the desired effect, the turnover problem is endemic to industry, so at best such an investment policy would divert labor from other industry. 25X1

The shortage of skilled repair workers has been cited as the main reason many plants are operating below capacity. The use of unqualified workers has caused

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the quality of repair services to deteriorate substantially during the last few years. Machine downtime usually exceeds plan levels, but, in the last five years, the difference between planned and actual downtime has widened. The amount of downtime for the larger kilns has increased by 30 to 40 percent since 1975. A lack of spare parts has prolonged repair periods. At least 25 percent of industrial accidents in the cement industry have been blamed on poor-quality spare parts. In one case, low-quality bearings forced a sudden kiln shutdown that destroyed the refractory lining and deformed the kiln only a few days after major repairs had been made. In another case one large kiln was down more than half a year because of accidents, most of them caused by poor repairs. [redacted]

Although the number of repair workers grew rapidly during 1976-80, the number and average skill level per ruble of capital stock declined. Further, the demand for repair work has increased faster than additions to plant and equipment. In contrast to smaller and newer kilns, aging equipment requires proportionately more repairs, as do the large kilns. The shortage of repair workers, especially with the relevant training and experience, prolongs downtime and diverts workers from performing scheduled repairs and maintenance and even kiln relining. The long-run effect of this neglect—found practically throughout Soviet industry—is to increase the incidence of machinery breakdowns. Although repair workers make up about one-fifth of the industry, V. S. Karelin of the Scientific Research Institute of the Cement Industry argues that 30 to 40 percent of the labor force should be devoted to repair. [redacted]

Cement plant managers, in adjusting to labor shortages, have curtailed their staffs of repair workers, employing them instead in production, and then subcontracting the repairs. Centralized repair trusts perform more than 70 percent of capital repairs. These trusts, however, also are understaffed, so that cement plants lose production time while awaiting the arrival of roving repair teams. According to Soviet studies, plant capacity use is considerably lower at plants that rely on contracted repairs than in plants that do their own repairs. [redacted]

Technical Progress Fails To Offset Problems

Research on cement is performed by the Ministry of Construction Materials, and research on concrete is conducted by the Ministry of Construction. This separation in R&D has had some unfortunate consequences for the industry. One cement research project, for example, developed ways to reduce fuel use during production but failed to allow for the resultant prolongation of hardening times that resulted in even greater consumption of fuel [redacted]

The pilot research plants, furthermore, deal either with developing new properties for cement or with plant applications. No institutions bridge the gap. Research institutes have made substantial progress, for example, in developing polymer cements, but introducing these cements into commercial production has been extremely sluggish. Quick-hardening cements were developed 10 years ago but still are produced only in negligible quantities. Sometimes research funds have been spent in areas with no clearly commercial applications. These practices have slowed the introduction of new technology. [redacted]

A recent article in *Trud,* entitled "The Price of a Mistake," detailed the failure of the cement industry to implement dry-process technology. In the late 1960s, several research institutes worked out this new technology. By 1982, only one plant had successfully introduced it; two had achieved only 50 to 60 percent of design capacity; and three were under construction for five years and are now nearing completion. [redacted]

In another case, several years of research developing a process to restore the strength of cement went for naught because of a lack of components. Although Soviet cement should be used within two months, [redacted] this seldom happens, and reportedly more than 70 percent of cement is significantly below its optimal strength by the time of its use. Nonetheless, the research project that discovered an energy-efficient way to restore cement strength using electromagnetic devices was canceled because the necessary components were available only to the Ministry of Defense. [redacted]

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Outlook

Soviet planners and policymakers are well aware of the shortcomings of the cement industry. They have responded by setting goals for increased output, improved quality, and energy savings, but have allocated only token increases in investment.

1981-85 Plan

Cement production is planned to increase by 16 million tons by 1985, an average of 2.4 percent a year from 1980. This represented a considerable acceleration from the annual growth of 0.5 percent a year recorded during the last half of the 1970s. Two years into the plan, however, output was 1 million tons less than in 1980. By the beginning of 1984, production was only 3 million tons more than in 1980. To reach the 1985 goal would require production increases of more than 5 percent a year in 1984 and 1985. The five-year plan calls for no further increase in average cement strength, perhaps an official recognition that further increases in quality would impose heavy energy costs and limit the tonnage availability of cement. This curb on average quality increase will penalize the lower priority consumers, because deliveries of high-quality cement to the military, nuclear power, and oil and gas industries probably will continue to increase. However, sacrificing strength to boost output exacts a toll on the economy, because more low-quality cement is needed to complete a construction project, and the project will require more repairs and have a shorter lifetime.

Raw Materials. Several steps are slated to ease the raw material shortages. According to the five-year plan, about one-sixth of the industry's capital investment is to go to opening new quarries or expanding existing ones. In addition, the ministry responsible for cement production will seek to share quarries with other ministries, thereby saving investment funds. Currently, 80 percent of quarry work is performed solely for the ministry in charge at a given location—for example, the Ministries of Construction Materials, Ferrous Metals, and Nonferrous Metals. One cement industry source estimated that nearly one-half the industry's mineral requirements could be met if it could share the quarries of other ministries. In particular, the ferrous and nonferrous metals industries are prime candidates for cooperation because of the compatibility of their geologic characteristics. Such a symbiotic relationship has a certain logic, but seems unlikely to work. First, interministerial cooperation probably requires a new system of incentives that would weaken the role of the ministries. Second, either the distance between quarry and existing cement plants would increase, putting even more pressure on the strained transportation sector, or new plants would have to be constructed near these deposits. Increased use of industrial byproducts is an alternative that also has been considered. The drawback here, however, is that the key products—slag and fly ash—are in increasingly tight supply.

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Energy. One goal of the 1981-85 Plan is to raise energy efficiency in the cement industry by 0.5 to 0.8 percent a year. Achievement of this objective depends on three basic elements: use of more byproducts to lower the cement's clinker content, increase of the share of dry-process plants, and development of new types of low-energy or clinkerless cements.

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Reducing clinker content depends on meeting the goals for increasing the share of portland slag cement—27 percent in 1980 to 30 percent by 1990. Such dependence reverses earlier deemphasis of portland slag cement as a way to improve the overall quality of cement. This new policy may be shortsighted, because it could lead to higher rather than lower energy costs; additional energy is required to turn the cement into concrete.[6]

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Conversion to the dry process is the most effective way to increase energy efficiency by 1985. In addition to the energy savings in the kiln, the dry process allows the introduction of preheaters, which yield significant energy savings. Despite recurrent calls to boost the share of dry-process plants, the conversion

[6] For example, the strength of slag cement is less than ordinary portland cement, the cement does not set as rapidly (so its use in precast concrete fabrication causes problems), and slag cement does not withstand cold temperatures very well. To compensate for the slow hardening, special additives and processes are required. Their production, in turn, uses more energy than that saved by producing portland slag cement rather than other cements.

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program has not really taken effect (table 3)—certainly not as rapidly as it has in most Western countries during the last 10 years (figure 2). Although geologic considerations would support the preponderance of wet-process plants, technological difficulties and investment stringencies seem to be mainly responsible for the delay in introducing dry-process kilns. Converting wet-process plants or building new dry-process plants requires large investment expenditures at a time when investment allocations are tight. Furthermore, conversion requires at least three years, and production is reduced by 25 percent during that time. The theoretical maximum share for the dry process in the USSR is unknown, but Soviet cement experts agree that there is considerable room for improvement.

Capital. The cement industry is to receive 1 billion rubles for investment during the 1981-85 plan period, roughly an 11-percent boost over the last half of the 1970s. There was a heated discussion in a 1979 issue of *Tsement* over how these limited funds are to be apportioned, with at least three schools of thought. Some favor modernizing wet-process plants, others building dry-process plants, and a third group converting wet-process plants to the dry process. A second debate centers on the order in which improvements should be made. One group argues that the smaller, older kilns should receive attention first because they are the least efficient. The other side submits that the newer, bigger kilns should receive priority because of their much greater impact on overall output. However these discussions turn out, we do not believe that the investment is sufficient to significantly modernize the industry's capital stock or to halt the decline in capital productivity.

Labor. The cement industry is to receive little, if any, increase in labor. Industry leaders hope to use the existing labor force more efficiently and are planning an average annual increase of 2.4 percent in labor productivity during the 1981-85 period, nearly 2.5 times the rate achieved in the 1976-80 period.

To accomplish this acceleration in the growth of labor productivity, the Soviets are relying on many of the same factors as planned for other sectors of industry: investment in high-productivity machinery; mechanization of repair work, auxiliary tasks, and materials-handling and freight-handling operations; introduction of automated control; improved social and cultural conditions; and reduced labor turnover. Because most of these factors depend on higher rates of growth of capital investment than is slated, the likelihood of a spurt in labor productivity is scant. 25X1

Foreign Trade as an Option

Foreign trade is always an option the Soviets could choose to relieve domestic shortages; they could:

- Import the raw materials.
- Import cement.
- Cut exports and retain more for domestic consumption.
- Import Western machinery and technology as a way to ease difficulties in the cement production process.

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We believe that importing the raw materials used for the cement production process is not feasible. Raw materials are bulky and expensive to ship, given the large amounts and long distances required. In addition, using foreign sources of raw materials would ease only one of many bottlenecks affecting this industry. 25X1

The Soviets could import the final product—cement—thereby avoiding the need to produce ever-increasing amounts of cement. Here too, however, there are important constraints. Like raw materials, cement is bulky and expensive to ship long distances. In the United States, for example, rather than a national market for cement, there is a network of small regional markets. Because cement is perishable, it must be shipped in special railroad cars. The shortage of these cars makes imports from long distances impractical, especially with the already heavy burden on the Soviet transportation system. 25X1
Thus, the opportunities to import cement usually are limited to small volumes of special cements and nearby countries, as is now the case. 25X1

Cost considerations aside, boosting imports from Eastern Europe is a possibility. Together these six countries produced in 1981 almost one-half as much cement as the Soviet Union (see table 8). Undoubtedly, however, much of this is needed for their own use. Moreover, total cement output in these countries has 25X1

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Table 8
Production of Cement in Non-Soviet Warsaw Pact Countries

	Output (*million tons*)	Rate of Growth (*percent*)
1970	42.1	
1971	44.6	5.9
1972	47.0	5.4
1973	50.9	8.3
1974	54.8	7.7
1975	58.1	6.0
1976	61.9	6.5
1977	65.6	6.0
1978	68.2	4.0
1979	66.6	−2.3
1980	66.1	−0.8
1981	61.1	−7.6

declined since 1978, primarily the result of the industrial upheaval in Poland. Even excluding Poland, there has been practically no growth in production. Therefore, purchases from non-Soviet Warsaw Pact countries probably do not offer a real alternative for the USSR.

Decreasing exports is a third option. The Soviet Union is a net exporter of cement—roughly 2 percent of its production (see table 1)—with deliveries in the 1980s mainly to Hungary, Yugoslavia, Saudi Arabia, Egypt, and Jordan. In the two years of significant production declines (1979 and 1982), gross exports decreased, although not enough to fully offset the production declines. Much of the exported cement probably is of less-than-average quality. Even if exports were stopped entirely, however, domestic availability would increase by roughly only 2 percent.

The final option consists of importing Western equipment or technology. The Soviets could profit from use of some of the newest dry-process kilns and preheaters, grinding mills, and materials-handling and measuring equipment. With continuing hard currency constraints and uncertainties about future needs for grain imports and equipment for the energy, agriculture, and transportation sectors, it is unlikely that cement equipment will be given a high enough priority to warrant the massive purchases required. Foreign technology, however, can help marginally by improving the technology of a relatively small number of plants. It cannot resolve the problems of the industry.

Prospects for the 1980s

Without foreign trade as an alternative, the problems of the cement industry become more significant. Failure to solve those problems—particularly shortages of raw materials and energy, an inefficient capital stock, and shortages of skilled labor—means that cement production will not return to earlier growth trends. In some years, particularly those of unusually harsh winters, output may decrease. 25X1

In turn this scenario will constrain the nation's ability to acclerate growth in new construction. Cement and concrete products account for about one-fifth of material inputs to construction. With possible substitute materials also in short supply, the importance of cement is unlikely to decrease. If this situation is accompanied by a continuation of the growing demand for hard-to-produce specialty cements by the military, atomic power, oil, and gas industries, the burden of reduced growth will fall more heavily on other users of cement. 25X1

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